New SLR-based geocenter estimates for orbit centering and impact on altimeter sea surface analysis
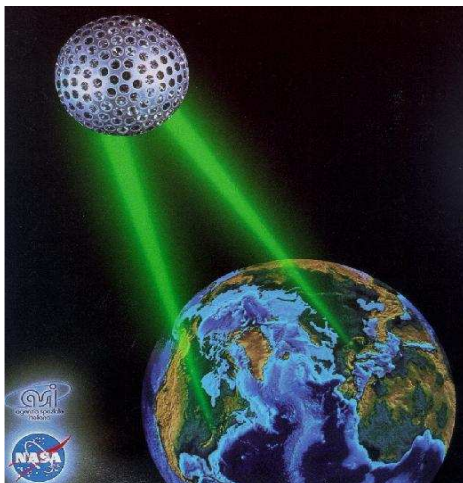
N.P. Zelensky[1], F.G. Lemoine[2], D.S. Chinn[1], B.D. Beckley[1], D.E. Pavlis[1]

[1] *SGT Inc., Greenbelt, Maryland, U.S.A.*
[2] *NASA Goddard Space Flight Center, Greenbelt, Maryland, U.S.A.*

OSTST POD
La Rochelle, France
**November 2, 2016**

Rationale - Improve SLR+DORIS orbit centering

Issue -

1) The Ries 2013 earth Center of Mass (CM) model improves orbit centering and has been adopted in the CNES and GSFC POD standards (Couhert et al., 2014; Zelensky et al., 2014).

1) However due to inconsistency, the Ries CM as well as any other available SLR-based model should be used alone, and not with the application of non-tidal station loading. This precludes further orbit improvement in this regard. (Zelensky et al., 2014).

1) Our analysis evaluates the determination and use of a CM model consistent with the application of atmosphere pressure loading. LAGEOS-1/2 data are used for CM estimation.

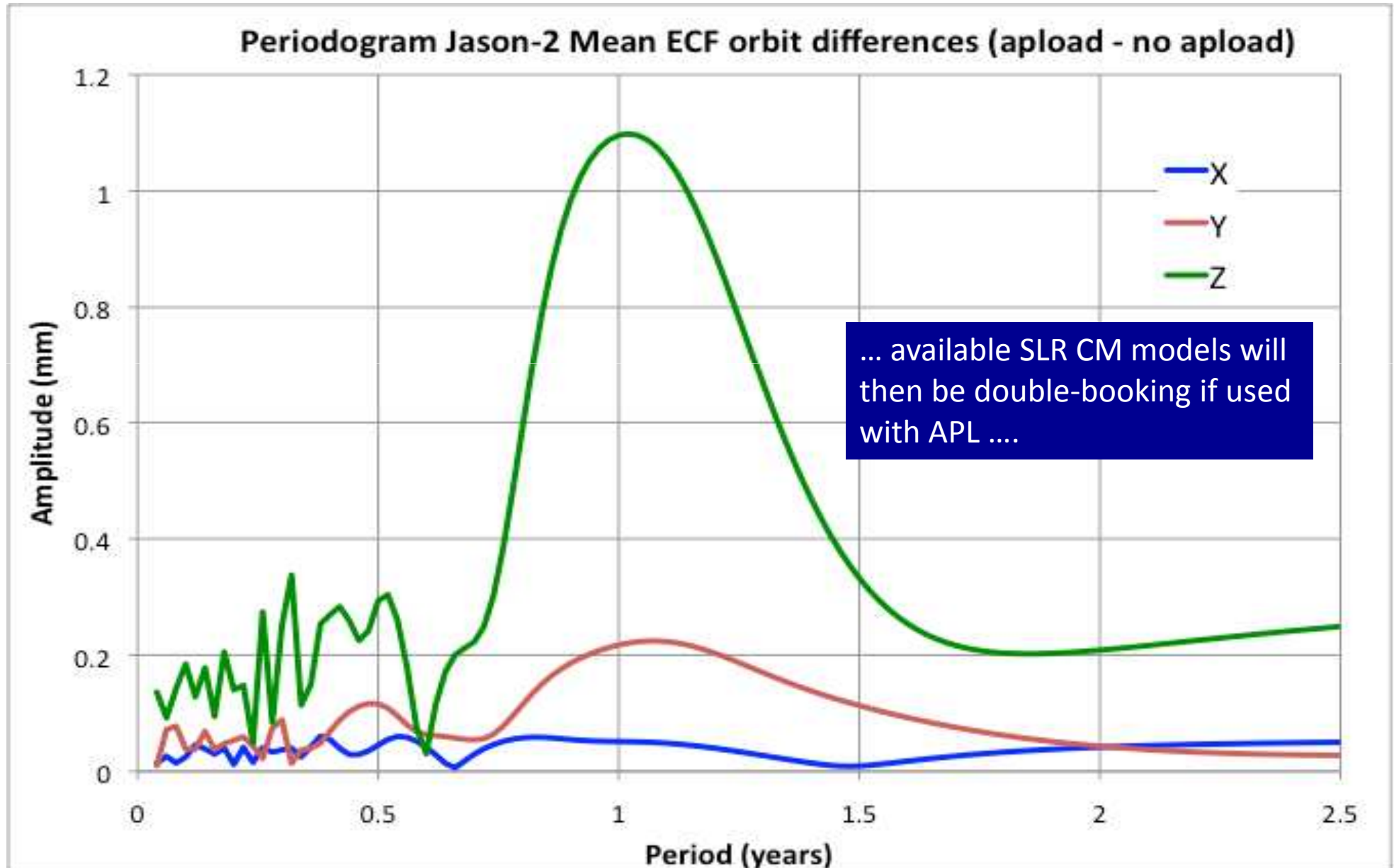# Earth Center of Mass (CM), Center of Figure (CF), Center of Network (CN)

Courtesy Wu et al., 2012
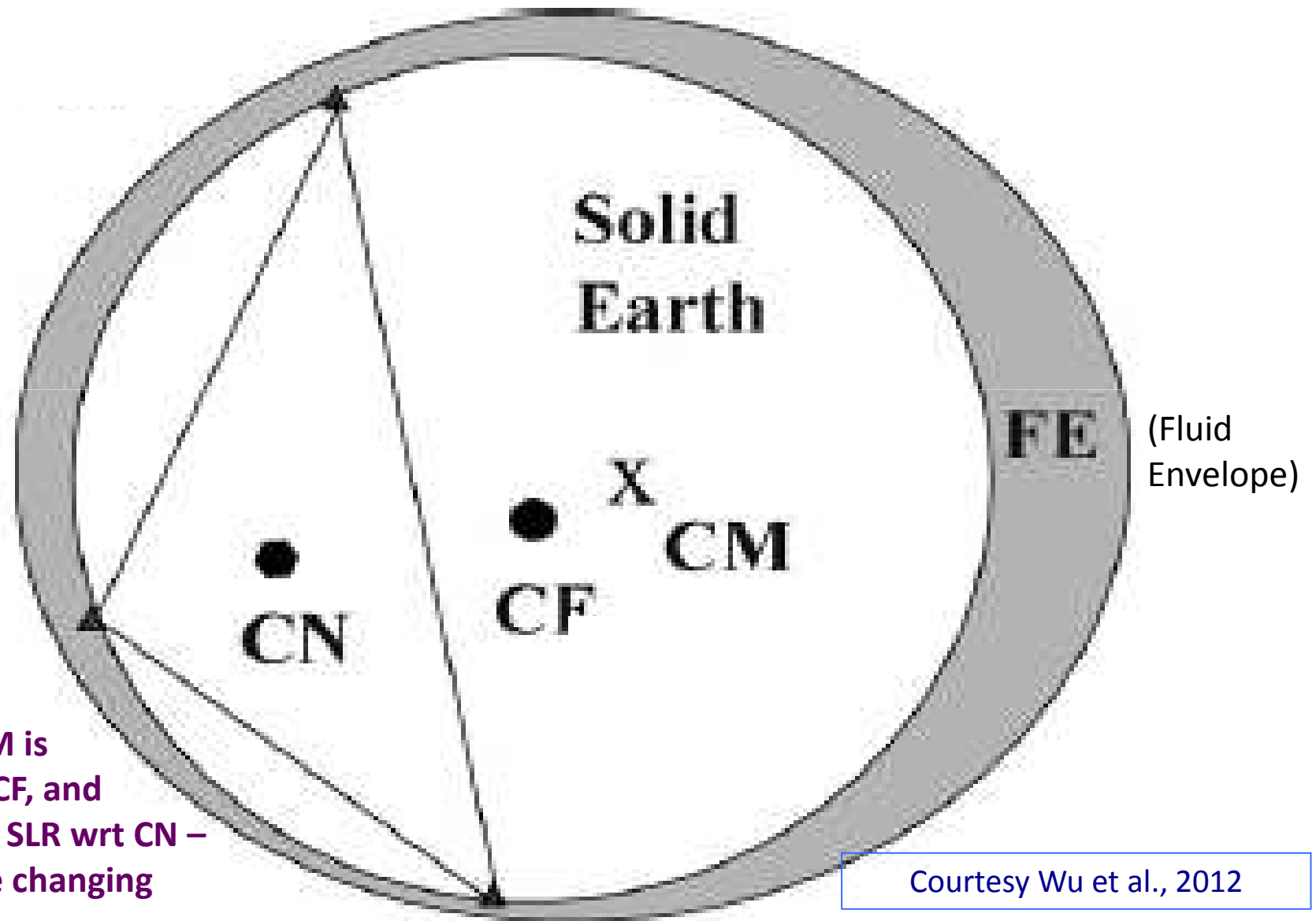
Conceptually CM is referenced wrt CF, and estimated using SLR wrt CN – CF, CN & CM are changing

Atmosphere Pressure Loading (APL) includes a Degree-1 Component: effect on Jason-2 orbit

Periodogram Jason-2 Mean ECF orbit differences (apload - no apload)

… available SLR CM models will then be double-booking if used with APL ….

Annual SLR-based CM Models are fits
(CM-CN; Amp*cos(θ-phase))

LAGEOS-1/2 14-day CoM estimates in Z

- l1+l2 estimates
- annual fit over 4-years
- Ries 2013 model

Estimate-series annual signal changes in amplitude and phase over time.
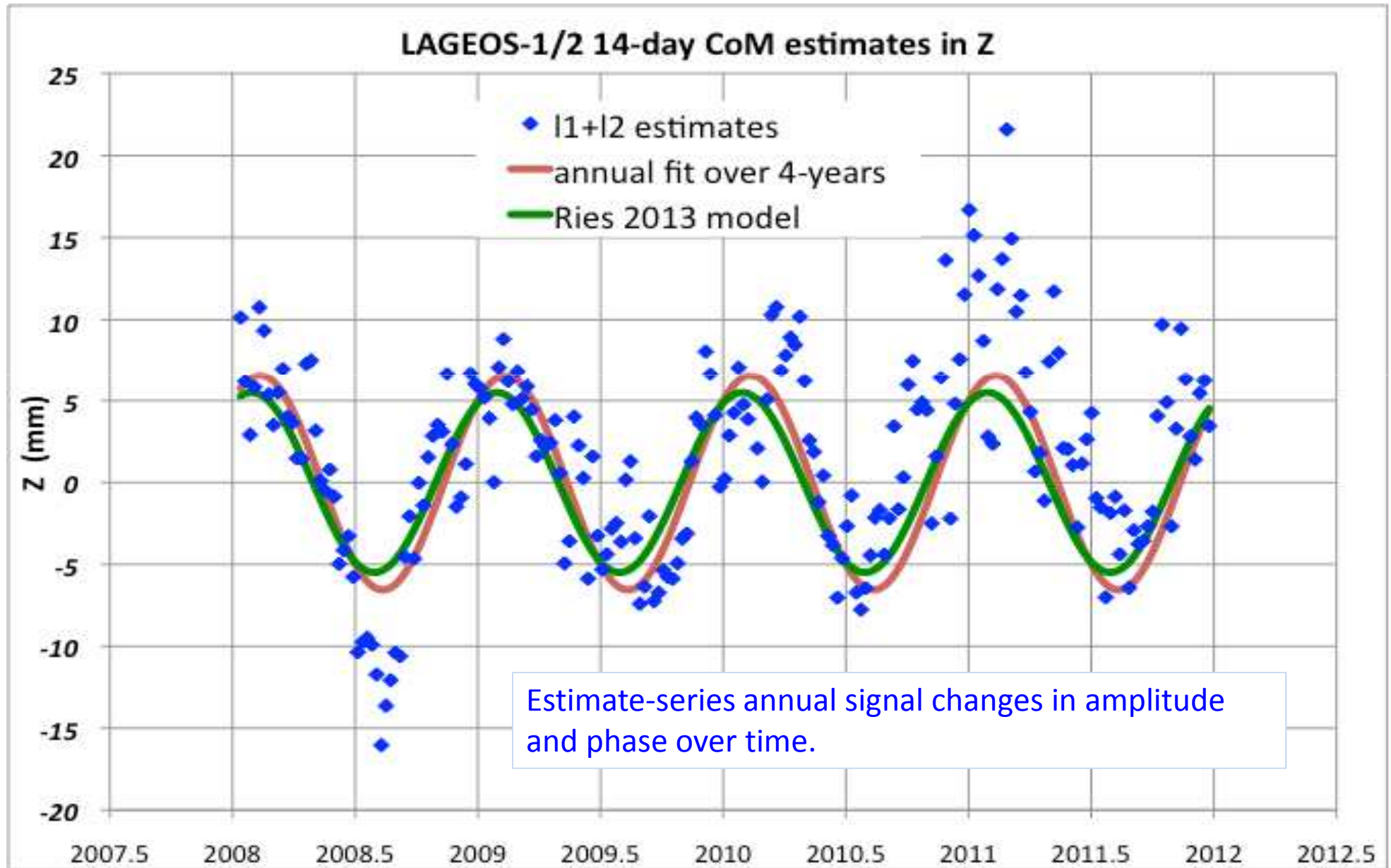
Annual SLR-based CM Models
(CM-CN; Amp*cos(θ-phase))

Model	X (amp)	X (phase)	Y (amp)	Y (phase)	Z (amp)	Z (phase)
Ries 2013 (15+ years) no APL	2.7	41	2.8	321	5.6	27
L1+L2 (8 yrs) no APL	3.3	50	2.4	303	5.8	46
L1+L2 (4 yrs) no APL	4.0	51	2.4	305	6.6	40
L1+L2 (4 yrs) with APL	3.5	60	2.0	289	5.1	61

Note.
1) GSFC L1+L2 CM estimates are ITRF2014-based (2008-2015)
2) Ries 60-day CM series, GSFC 14-day CM series
3) Other GSFC SLR-based CM solutions also included Starlette, Sella, Lares
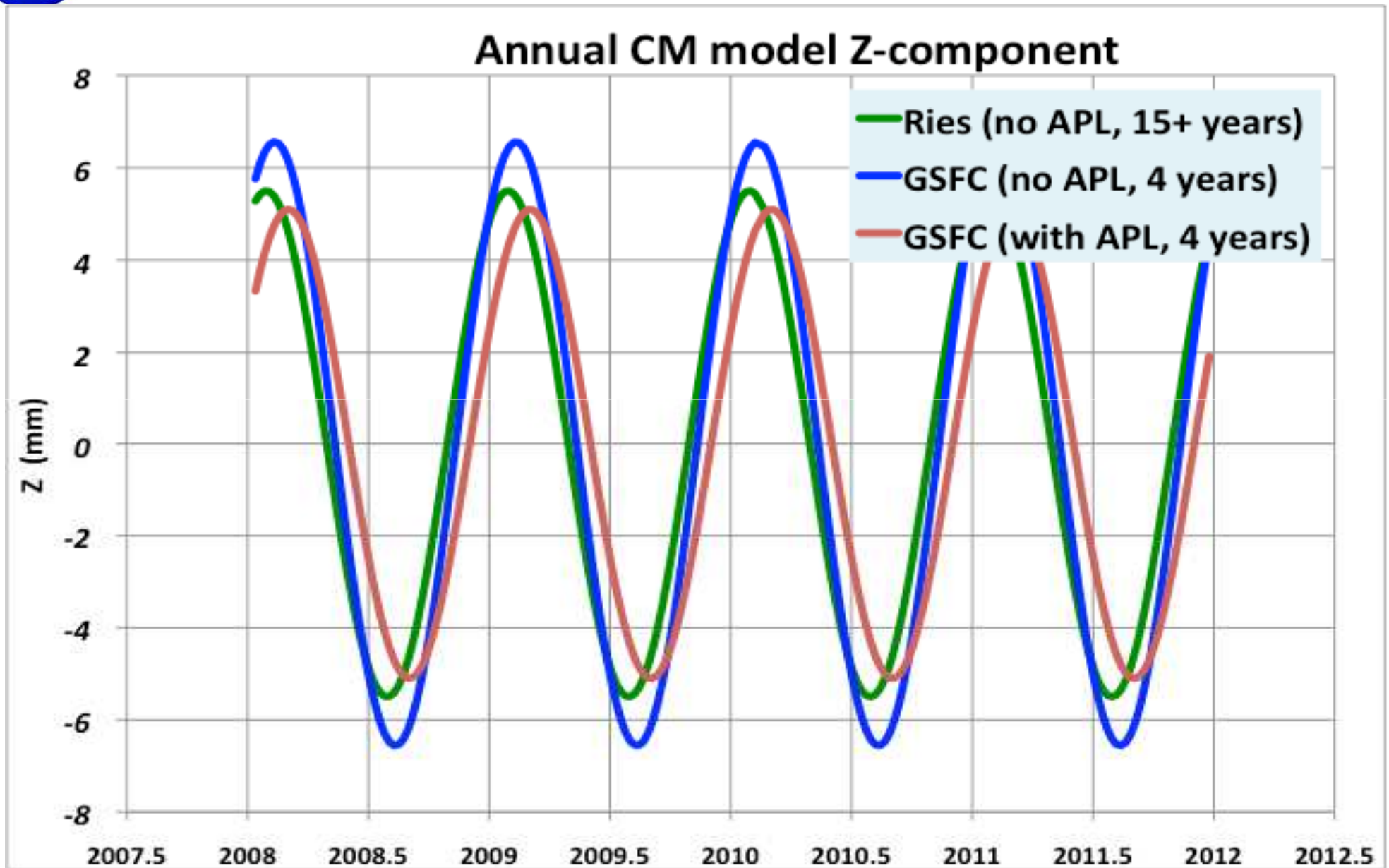4) APL from Tonie van Dam

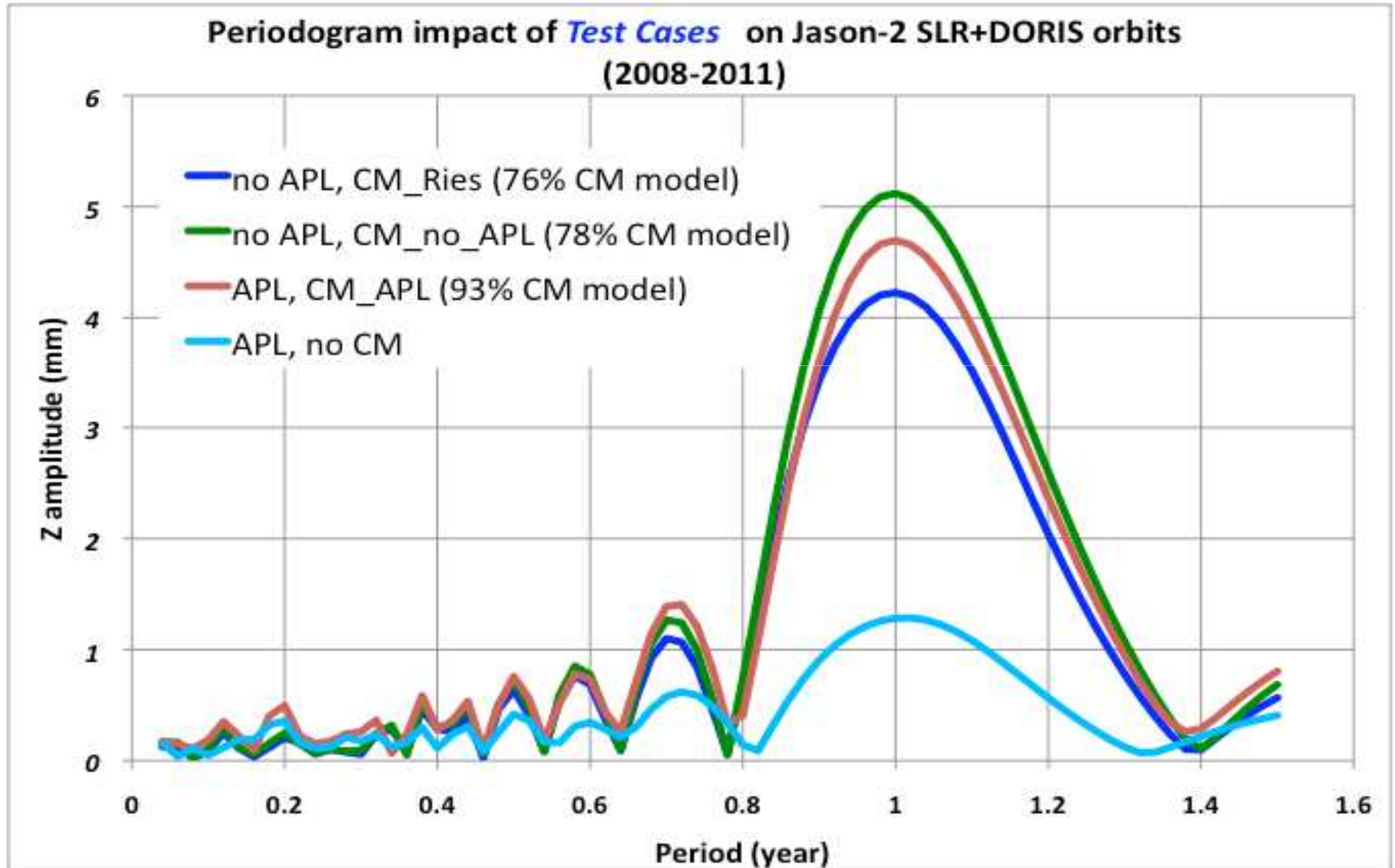# Atmosphere Pressure Loading and Improvement in LAGEOS-1/2 SLR Residuals
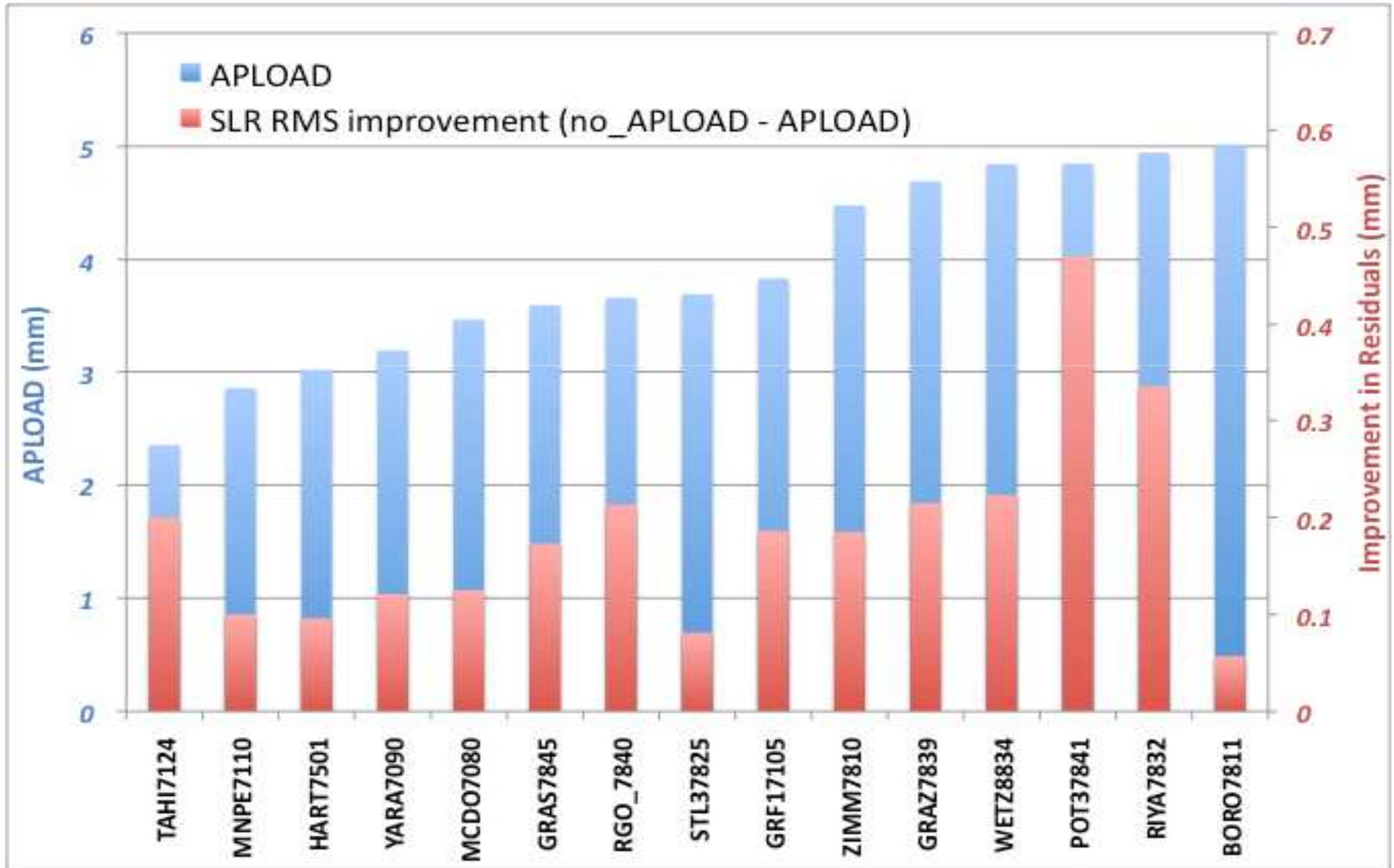
3 Annual CM models used in Jason-2 POD tests

CM model impact on Jason-2 orbit centering (no APL, no CM Orbit) – (Test Orbit)

Periodogram impact of *Test Cases* on Jason-2 SLR+DORIS orbits (2008-2011)

Impact on Jason-2 SLR+DORIS orbit centering – dominant Annual signal

Model	X (amp)	X (phase)	Y (amp)	Y (phase)	Z (amp)	Z (phase)
CM Ries	0.6	28	0.8	168	4.2	67
CM no_APL	1.0	32	1.1	189	5.1	55
APL, CM_APL	0.9	26	1.0	180	4.7	48
APL	0.0	---	0.2	92	1.3	98

Station position improvement ? - Jason-2 DORIS/SLR residuals

Test (080712 – 111231)	Consistency CM / APL modeling	DORIS (mm/s)	SLR (cm)
no APL, no CM	-----	0.3742	0.844
no APL, CM_Ries	yes	0.3741	0.838
no APL, CM_no_APL	yes	0.3741	0.838
APL, no CM	------	0.3741	0.835
APL, CM_APL	yes	0.3741	0.831

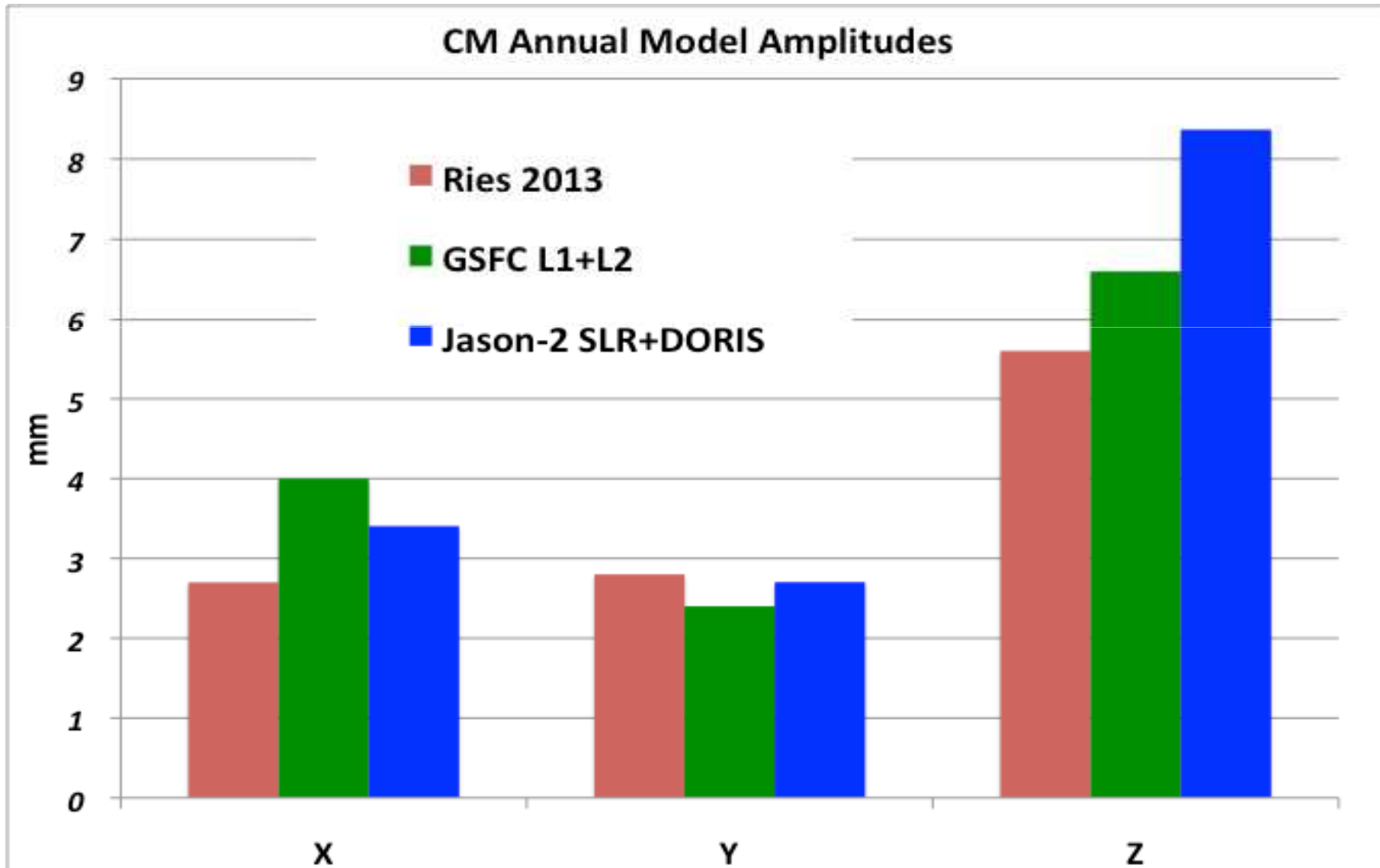Is the computed orbit origin better aligned with the instantaneous center of mass ?

Comparison with JPL GPS orbits not sensitive to variations in tests – apparently other signal present

Periodogram Jason-2 Mean orbit differences JPL13a - SLR+DORIS *Test* (2008-2011)
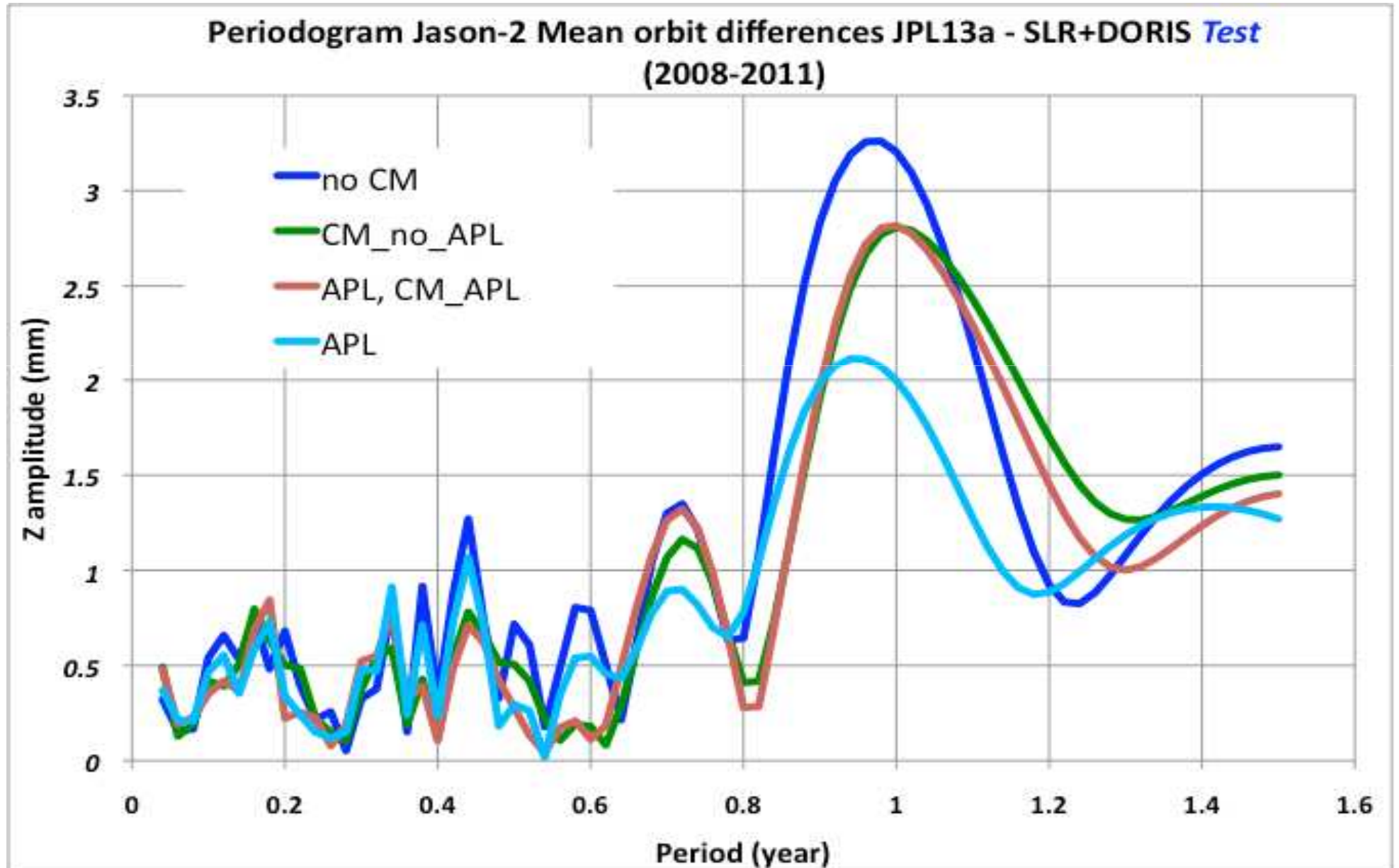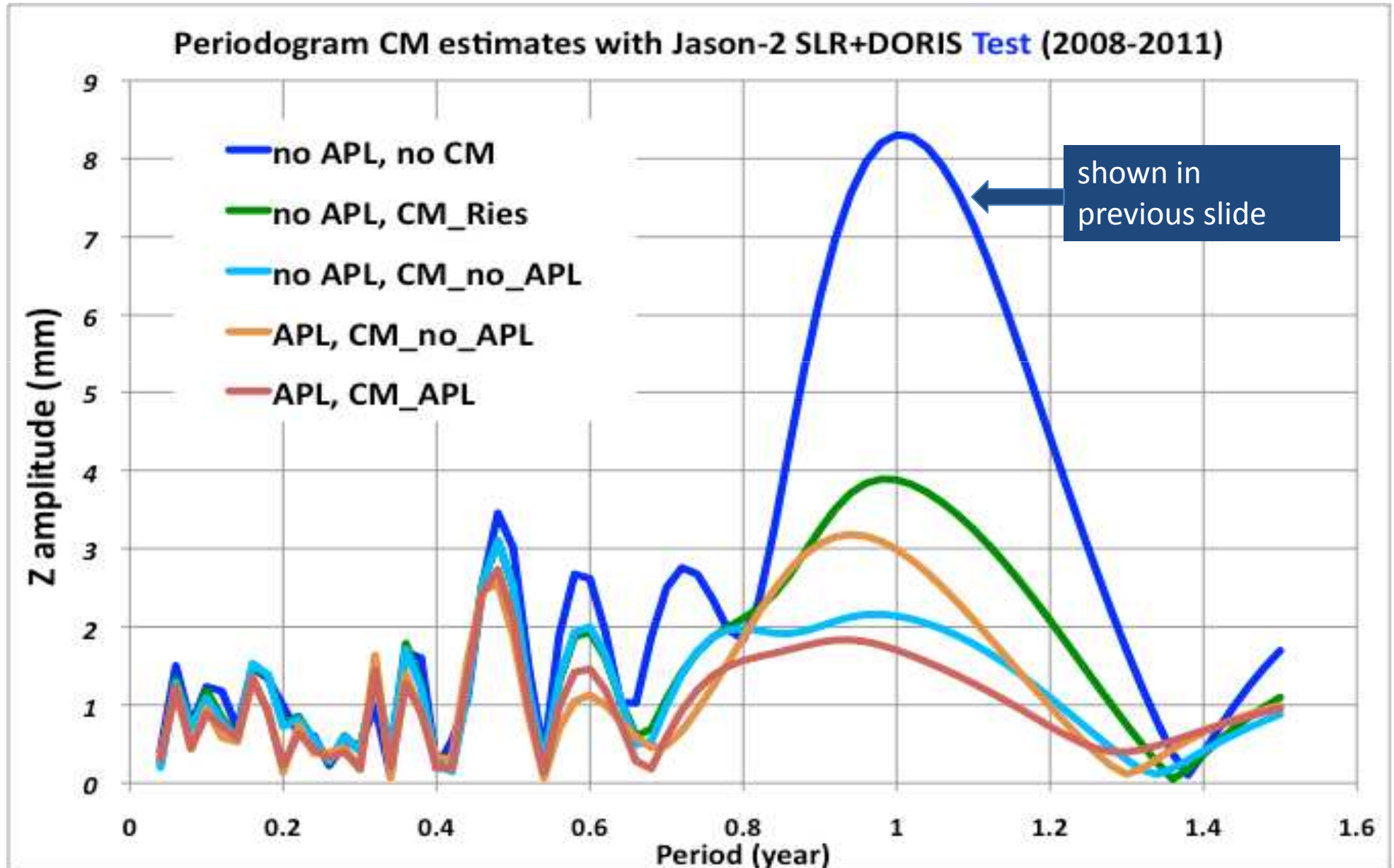
Is Jason-2 SLR+DORIS data sensitive to orbit centering improvement? – estimate CM series with Jason-2 SLR+DORIS data

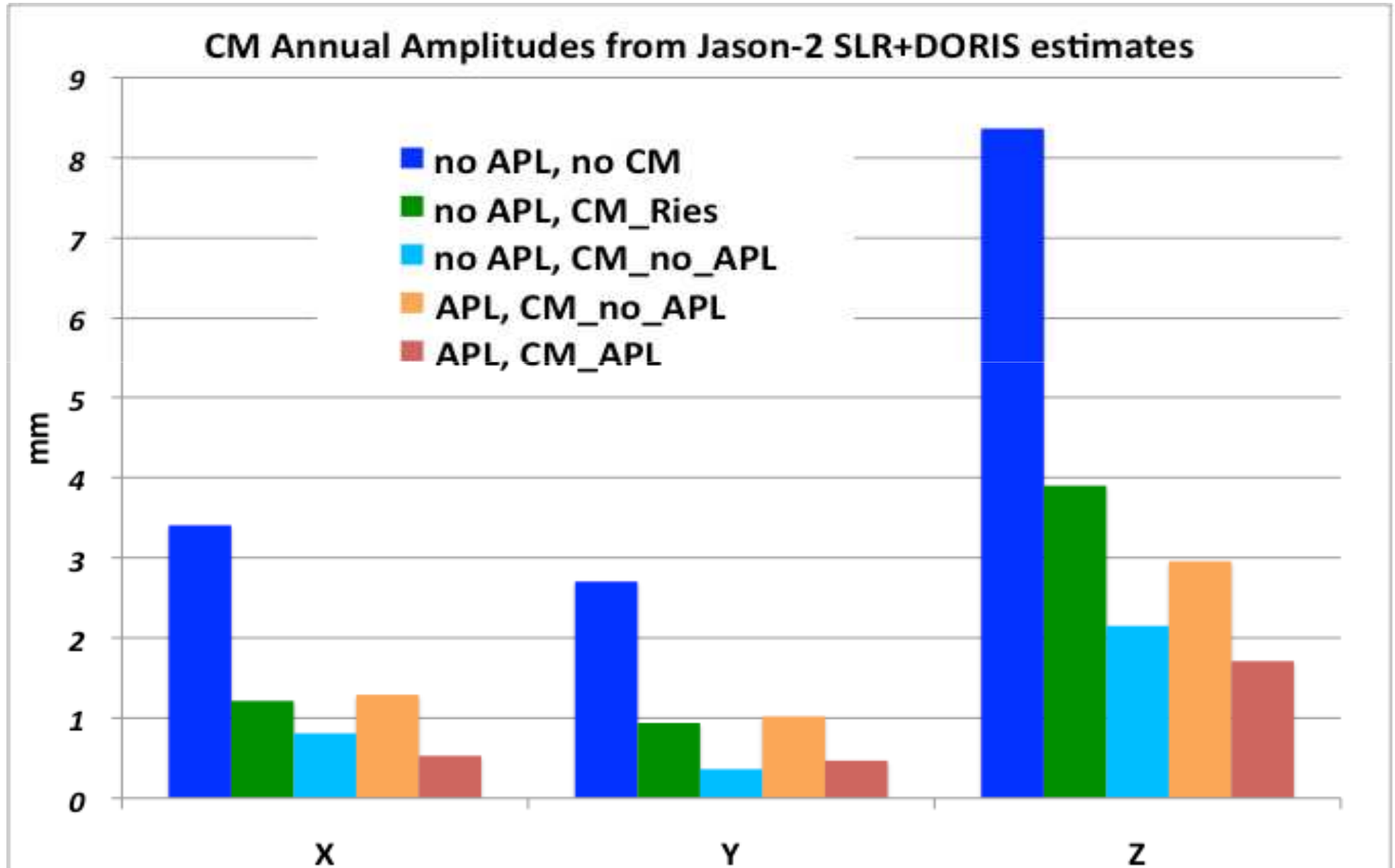# Use Jason-2 SLR+DORIS data with test models to estimate a Residual CM

Periodogram CM estimates with Jason-2 SLR+DORIS Test (2008-2011)

Legend:
- no APL, no CM
- no APL, CM_Ries
- no APL, CM_no_APL
- APL, CM_no_APL
- APL, CM_APL

shown in previous slide

Use Jason-2 SLR+DORIS data with test models to estimate a Residual CM

CM Annual Amplitudes from Jason-2 SLR+DORIS estimates

Legend:
- no APL, no CM
- no APL, CM_Ries
- no APL, CM_no_APL
- APL, CM_no_APL
- APL, CM_APL

Conclusions

- Goal to improve orbit centering and station position modeling with best application of CM, and not necessarily to achieve best definition of CM.

- At present further orbit improvement is precluded in this regard due to inconsistency between available SLR-derived CM models and use of APL.

- Station position modeling improved with CM, and further improved with application of APL.

- Evaluation of Jason-2 SLR+DORIS CM estimates shows orbit centering is most improved when using APL in combination with a CM model derived also using APL.

- Future studies will extend the analysis time series using JP Boy's APL data and 28-day estimates, and include analysis of altimeter data.

Thank you

2016 OSTST, La Rochelle, Zelensky et al
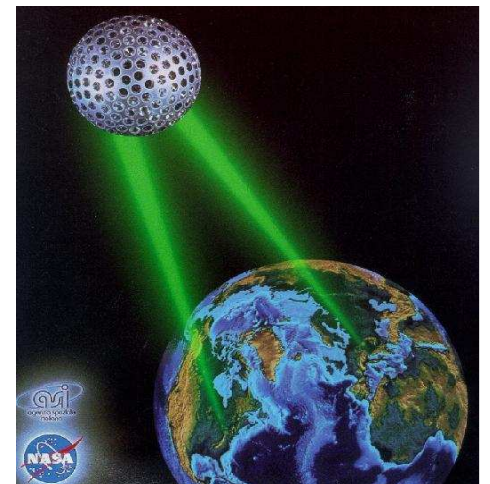
BACKUP

GSFC CM Estimate
Modeling of LAGEOS-1/2, Starlette, Stella, Lares solutions

0. IERS2010 (pole).
1. ITRF2014/Augmented. (stations). Elcut 12 deg.
2. GOT4p10 (ocean tides
3. Earth Tides. IERS2003
4. GOT4p10 (ocean loading).
5. Mendez model for SLR troposphere correction
6. Tidal EOP
7. Tidal Geocenter (GOT4p7).
8. Gravity. GOCO2S (static) + TVG (5x5 weekly solutions) +Annual terms from GRACE for L >= 5.
9. Adjust opr/along/cross + along-track constant/week for L1 & L2.
10. Adjust biases/station/arc (combined for L1, L2) except for thos suggested.in data handling file to use pass-by-pass biases.
11. For the combined runs (Lares, L1, L2; Starlette, Stella, L1, L2), the biases were adjusted per satellite rather than combined.
12. Atmosphere Pressure Loading applied as specified.

CM largely affects J2 SLR+DORIS orbit in Z